Cloud Properties from High Spectral Resolution Infra-Red Measurements Observed During CRYSTAL-FACE

Robert E. Holz, Steven A. Ackerman, Paolo Antonelli, Shaima Nasiri

University of Wisconsin-Madison, CIMSS

William L. Smith and Bryan Baum
NASA Langley Research Center

Overview

- NAST-I cloud property retrieval algorithm
- Current methods to derive cloud pressure from NAST-I data (MLEV and CO_2 slicing)
- A new algorithm to combine with MLEV and CO_2 slicing to improve cloud top pressure determination

Cloud mean effective diameter (D_{eff}) and Optical Depth Retrievals

Input parameters for retrieval:

I. Temperature and water vapor profile

II. Cloud top pressure

III. NAST-I observations between 8.5 -12 microns

Output:

I. Cloud mean effective diameter

II. Cloud optical depth at 11 microns

- Focus: The retrievals are sensitive to errors in cloud top pressure

Cloud Pressure Determination

MLEV (Minimum Local Emissivity Variance)

Strength: Accurate for optically thick clouds

Problem: Low sensitivity to optically thin clouds

CO_2 Slicing

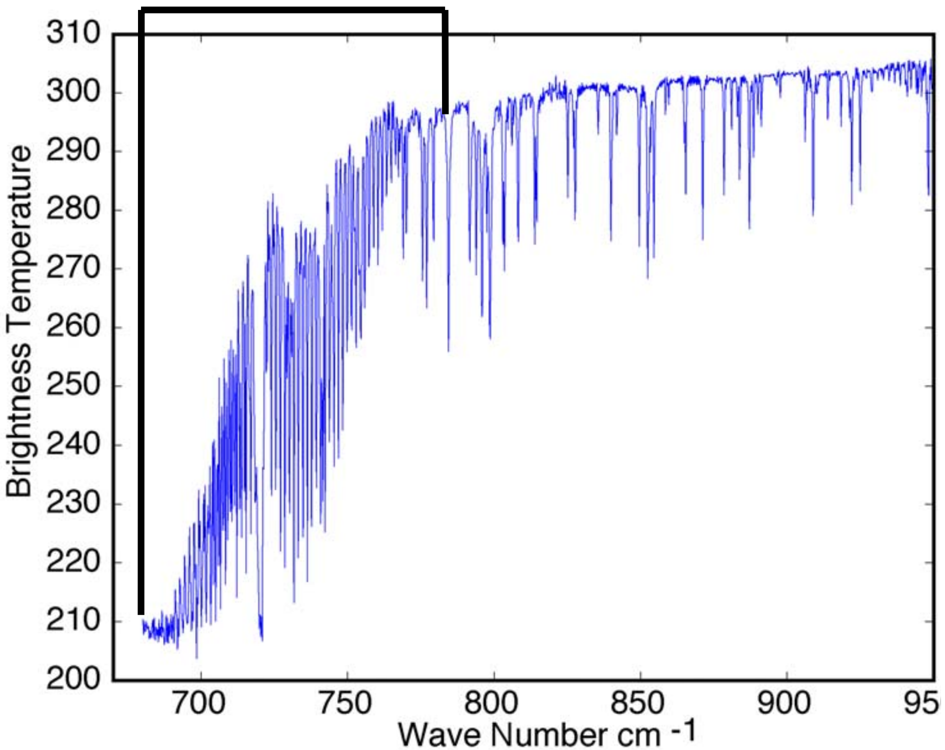
Strength: Insensitive to cloud fraction and capable of detecting thin clouds

Forward model required to simulate upwelling radiances

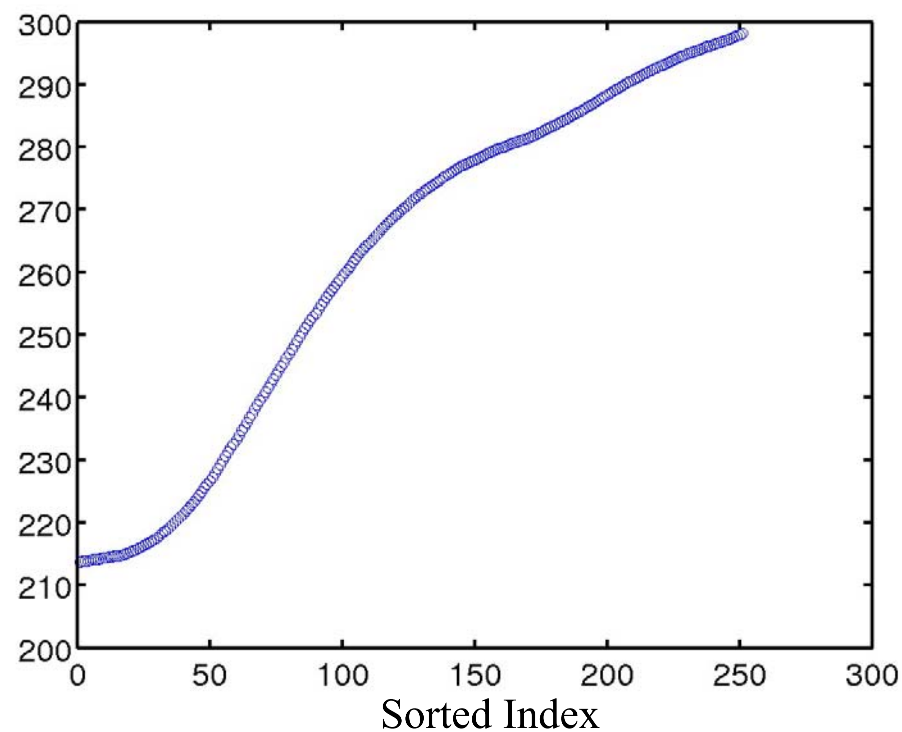
Problem: Optimal channels are a function of cloud top pressure

CO_2 Channel Selection Algorithm (CO_2 Sorting)

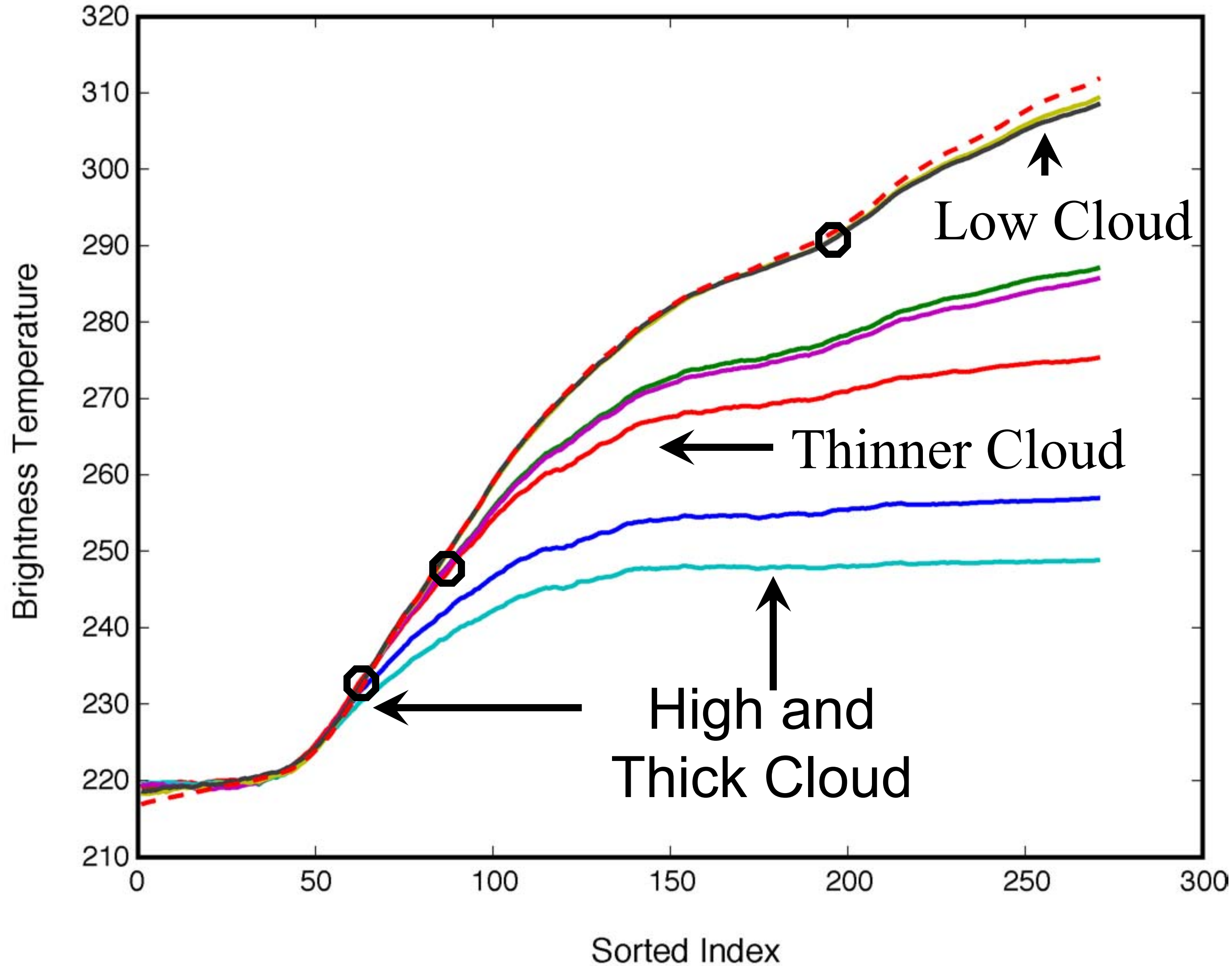
The selected clear sky CO_2 spectrum is sorted according to brightness temperature



The Sorted Clear Sky Spectrum

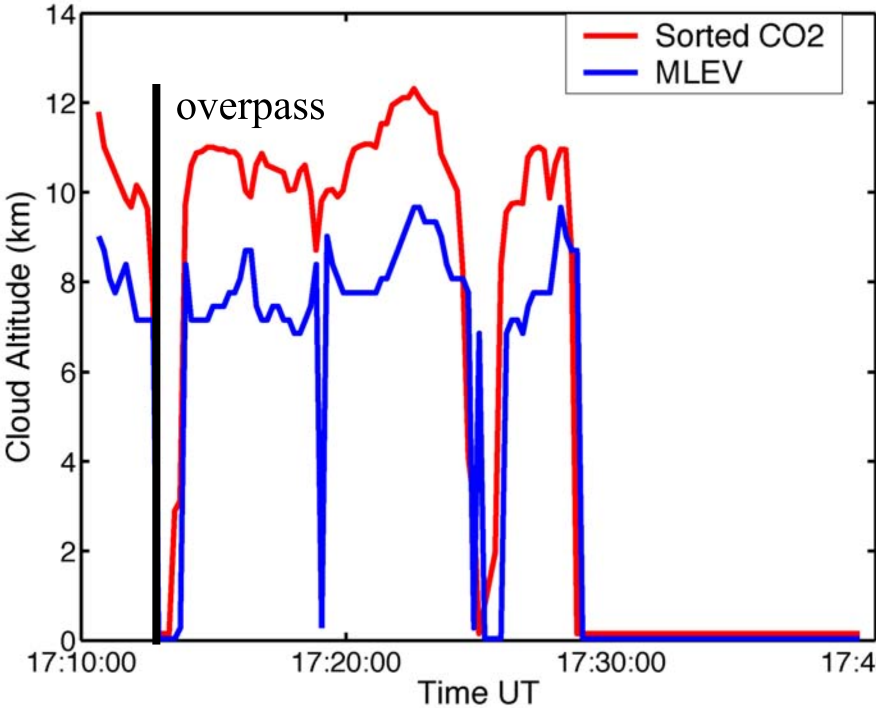


CO_2 Sorting: Sensitivity to Brightness Temperature

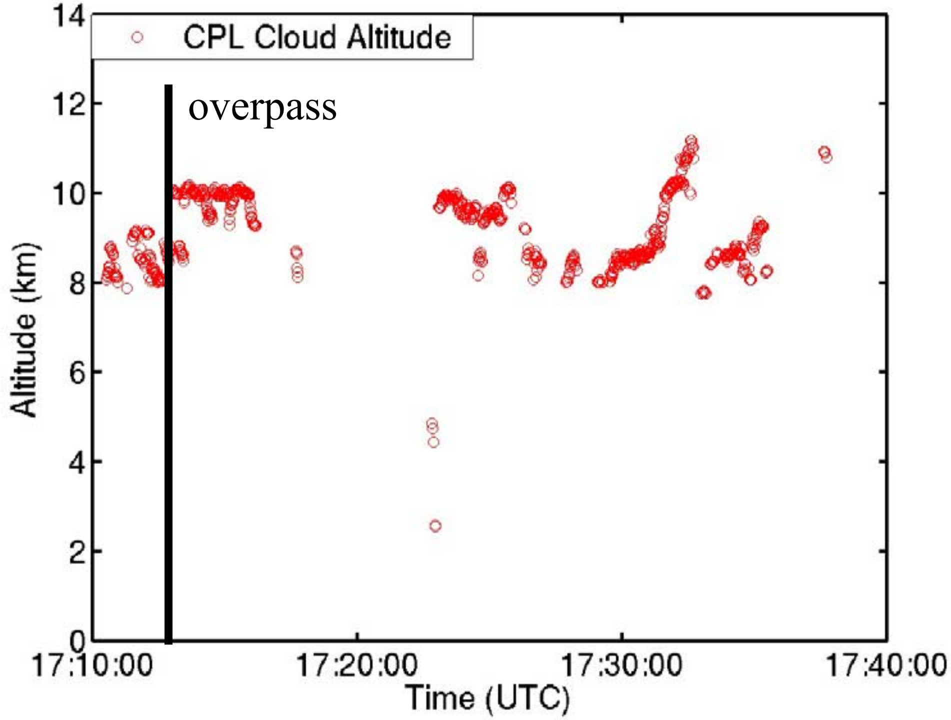


CO_2 Sorting: CRYSTAL July 3rd 2002

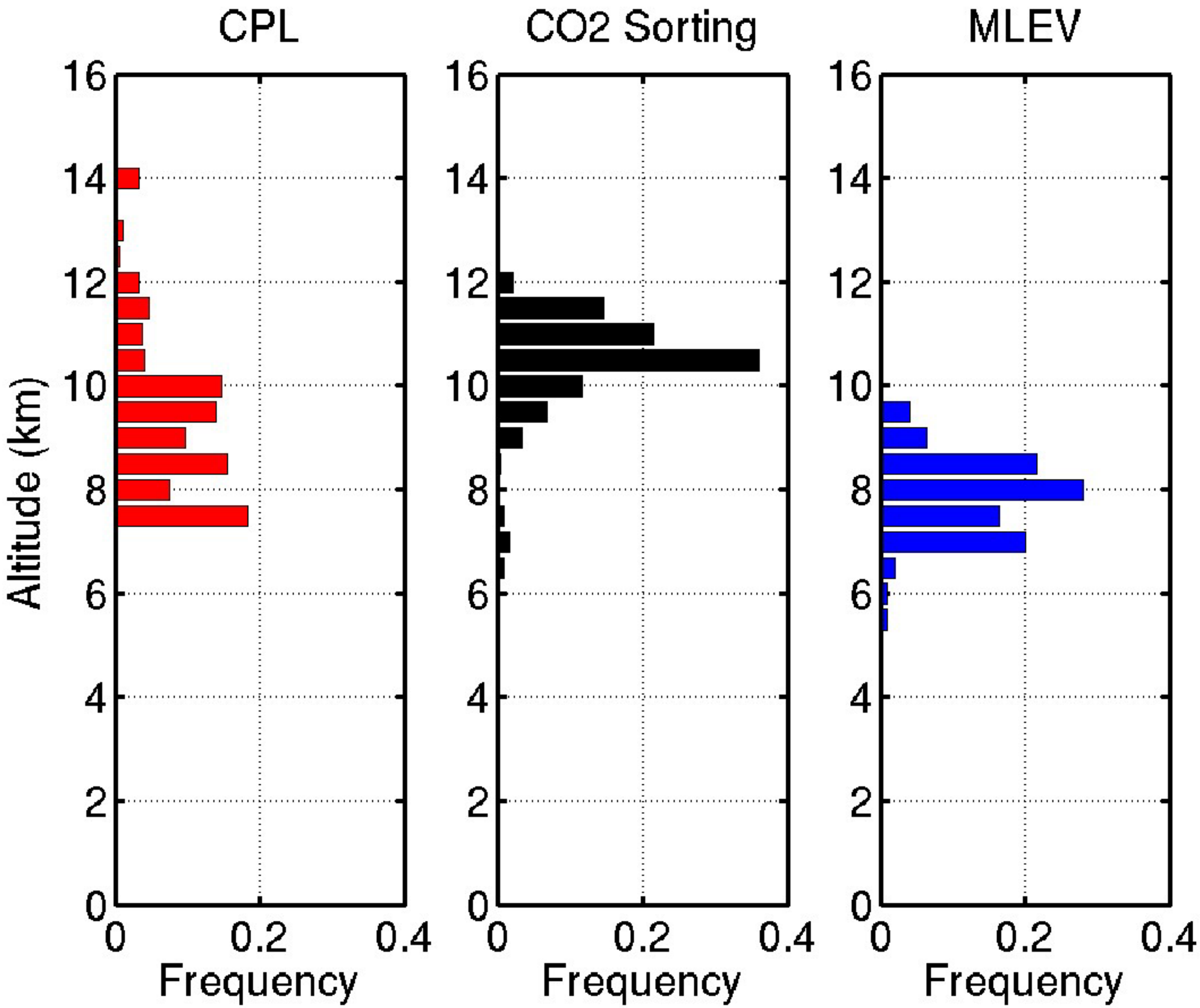
MLEV vs. CO_2 Sorting



CPL Cloud Top Altitude



Cloud Altitude Frequency of Occurrence
3 July, 2002 1600 - 1810 UTC



Summary

- Accurate cloud top pressure is critical for accurate retrievals of D_{eff} and optical depth (see Shaima Nasiri's poster)

- Demonstrated a new algorithm which uses the sorted CO_2 spectrum. CO_2 sorting shows promise for cloud top pressure retrievals and for choosing optimal CO_2 slicing channel pairs.

Future Work

- Reduce cloud top altitude bias
- Apply to more data: AERI (ground-based) and AIRS (satellite-based)
- Use CO_2 sorting to choose CO_2 slicing channel pairs.
- Apply the sorting algorithm to the H_2O band.
- Combine CO_2 sorting, CO_2 slicing, and MLEV.

Particle Size and Optical Depth Retrieval Procedure

- The retrieval is based on the comparison between simulated and observed radiances
- Simulated radiances are computed for 18 micro-windows between 8.5 and 12 μm
- The cirrus scattering calculations are based on three-dimensional randomly oriented ice columns assuming 6 different particle size distributions
- Multiple scattering calculations are performed for 26 different optical thicknesses between 0 and 20

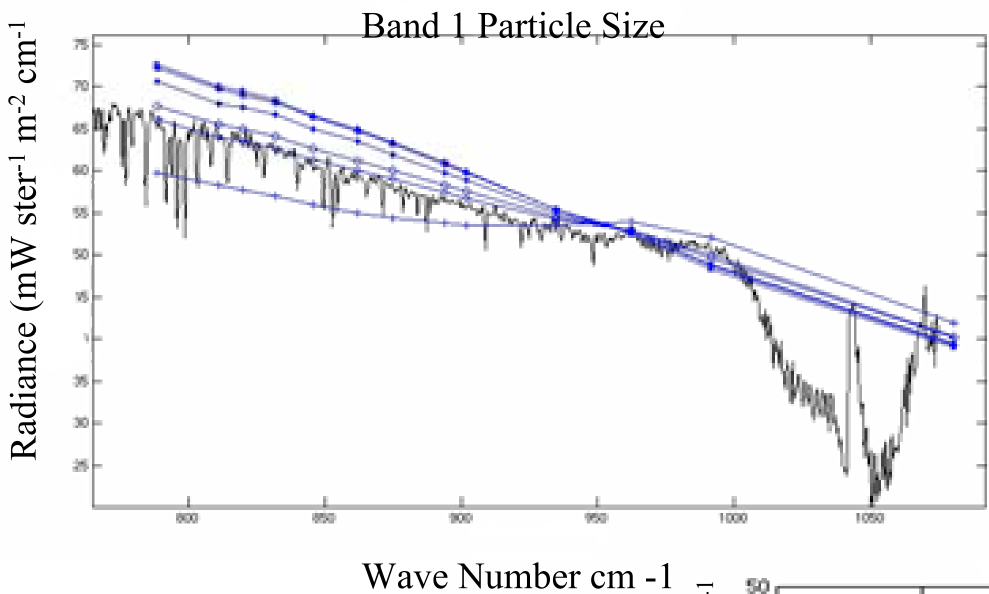
MLEV:Solving Equation

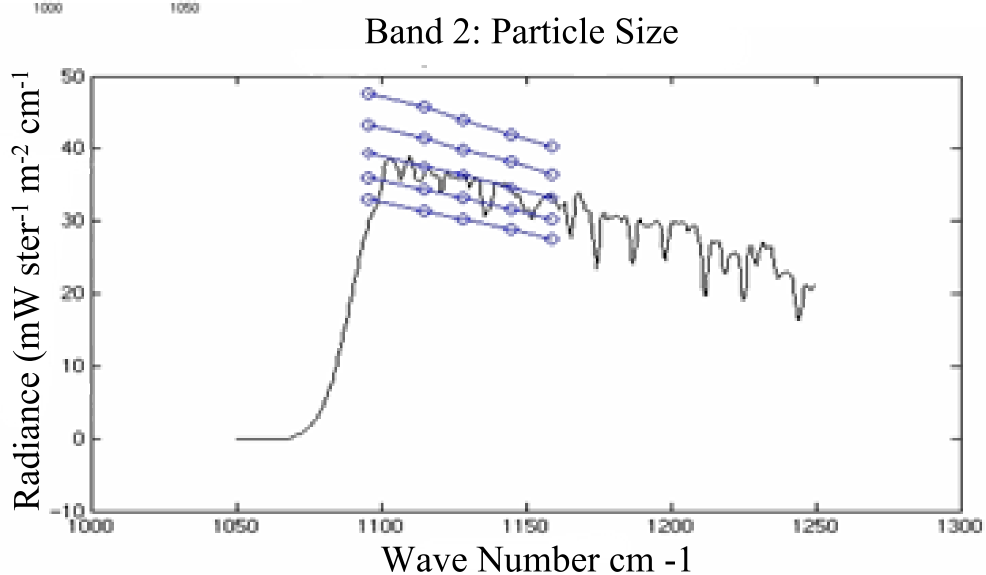
$$\eta(\nu) = \frac{R^{ob}(\nu)\text{-}R^{cl}(\nu)}{R^{cd}(\nu,p_c)\text{-}R^{cl}(\nu)}$$

Retrieval Uncertainties

- Particle shape
  - Retrieval assumes pristine columns in the simulated data. Plans underway to include other habits, e.g., bullet rosettes
- Particle size distribution
  - Plans are underway to include more expanded set of size distributions in the form gamma distributions (Heymsfield et al. 2002)
- The retrievals are sensitive to errors in cloud top pressure

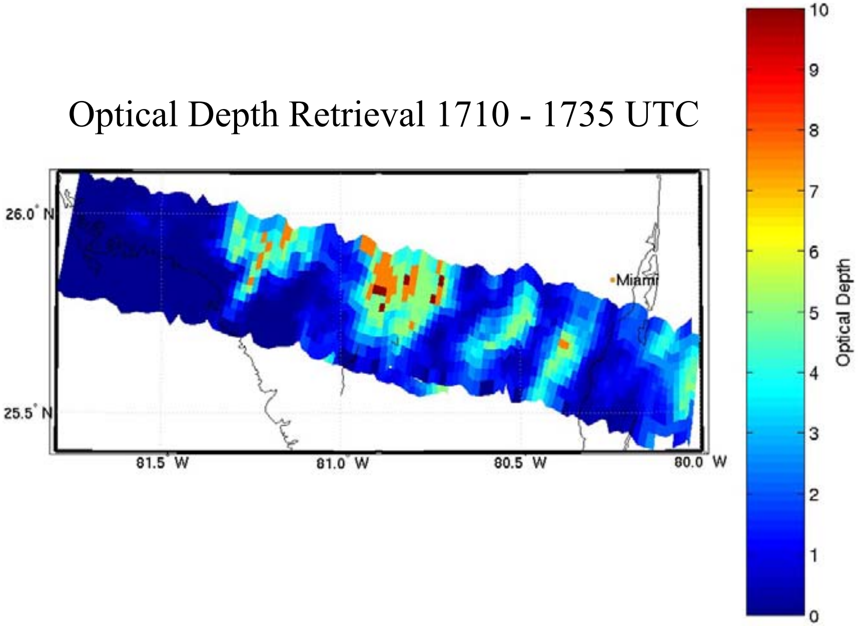
Cloud Particle Size and Optical Depth Retrieval



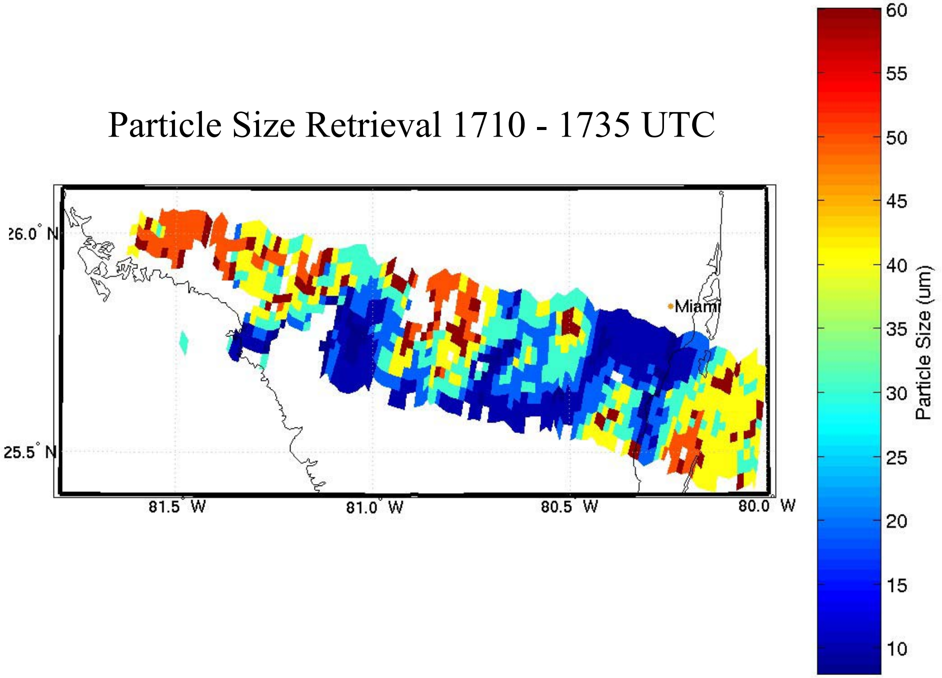


Particle Size and Optical Depth July 3rd 2002

Optical Depth Retrieval 1710 - 1735 UTC



Particle Size Retrieval 1710 - 1735 UTC



The PS and OD Retrieval Sensitivity to Cloud Height